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Abstract

IMPROVEMENTS IN INSTRUMENTATION FOR HIGH-PERFORMANCE POWER REACTORS

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Development of nuclear power plants capable of supplying low-cost power has required increased performance from the reactor core. In order that reactor performance will not be limited by instrumentation capability, new instruments have been developed, both for new functions not hitherto utilized and for improved realization of functions already used. Low power cost also requires high plant availability, and much effort has been expended in improving instrument reliability to this end. Some of the newly developed instrumentation techniques are described.

A major improvement in nuclear electronics for reactor instrumentation has been effected by the development of special-purpose modular instruments using solid-state active components. Besides the advantages of increased performance and reliability and decreased size and power requirements, these new modules can be combined to form instrument systems with greatly improved characteristics. A wide-range counting channel is described using continuous controlled motion of the sensor to obtain measurement of reactor power and period over the entire range of operation, without range switching or other discontinuities. Multiple reactor controllers have been developed in which failure of one measuring channel or one servo will not result in loss of automatic regulation of the process. Safety systems with complex input functions have been built using in-process

testing to assure adequate safety performance without sacrifice of plant serviceability.

Improved nuclear detectors described include compensated ionization chambers, multi-section chambers, high-temperature chambers, and a fission-chamber pulse-preamplifier assembly insensitive to electrical pickup noise. Non-nuclear instrumentation modules using solid-state components have been developed which give improved performance and reliability.

Special sensors are described for measuring non-nuclear variables in the reactor environment. Ultrasonic techniques are used to measure liquid level, or liquid foam vapor interfaces and foam density. Experimental sensors include sonic, ultrasonic, and reactivity detection of incipient boiling, pneumatic temperature measurement, and measurement of high temperature using variation of the dielectric constant of certain ceramics. In-core sensing of nuclear and non-nuclear variables is used to facilitate optimization of reactor performance and control.

The use of these new instruments and techniques is intended to increase plant safety, performance, and serviceability. The undoubted increase in the complexity and cost of instrumentation must therefore be offset by the above-mentioned gains, leading to lower overall cost with acceptable safety.